YYT-C3002 lecture 9: Software architectures and systems: stand-alone, connected, and cloud

Aalto University
School of Engineering

Contents of this lecture

- Different analysis environments
  - Computer: basics (problem-solving point of view)
  - Computer connected to the internet
  - Cloud platforms
- Software architectures
  - The three-layer model

The Computer

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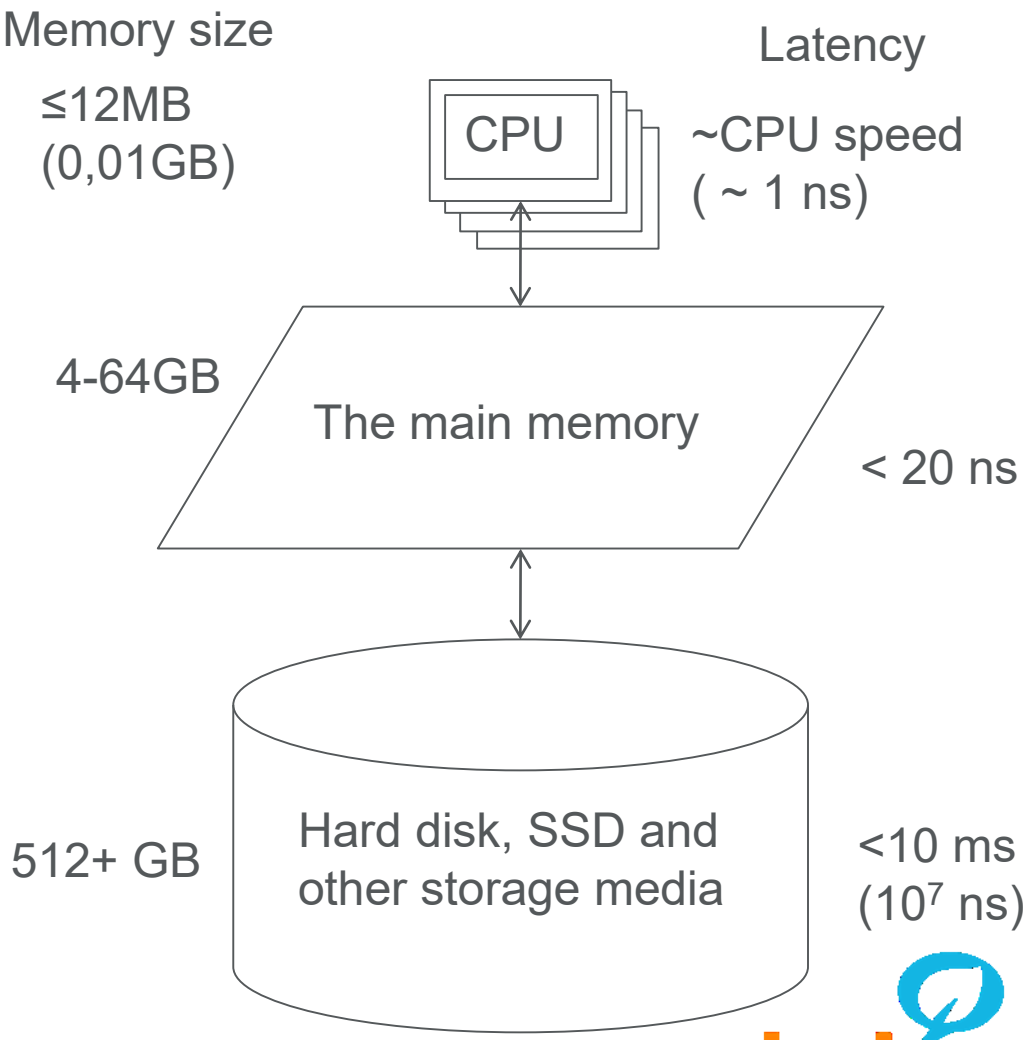
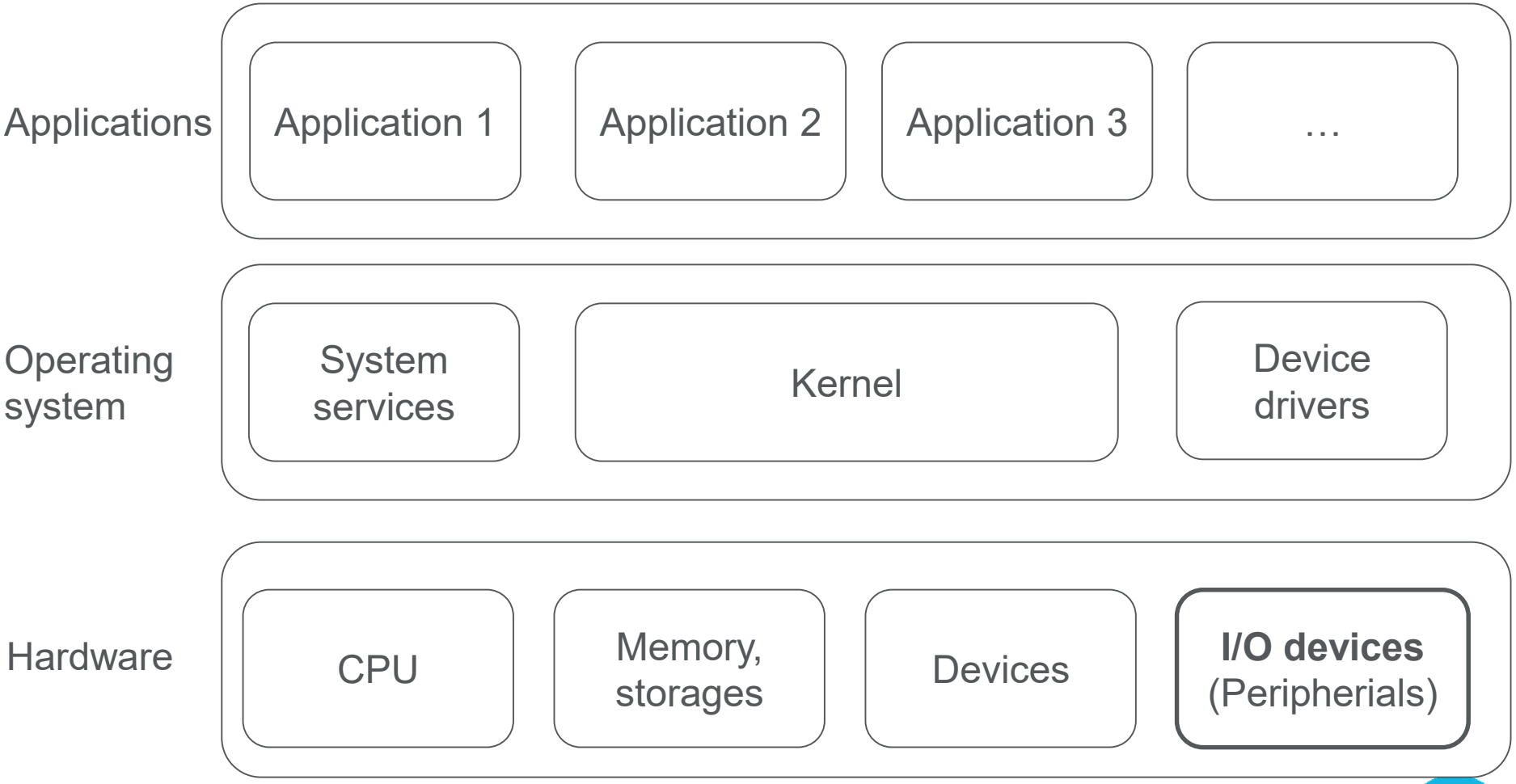
A (very) abstract model of computer hardware

- **CPU** handles the calculation
  - Very fast but small
  - Several cores
- Main memory stores working data
  - Reasonably fast and large
- External storage contains rest of data
  - Slow but extremely large
- Additional calculation done by e.g. graphics processors



A (very) abstract model of computer software



User interaction with a stand-alone computer

Source: http://jrdelectronics.com/portfolio-posts/traders-and-suppliers-of-computer-peripherals-mumbai/

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Engineering on the stand-alone system

When there’s no internet connection…

You are alone

Engineering on the stand-alone system

- Work is done on a local office computer
  - The system may be either standard computer or specifically intended for such analysis
- The engineer interacts with the data through engineering software, using tools available on the local machine
- The data is all available locally
  - In the file system
  - In a database
- Results will be stored locally
  - In the file system or in a database
- Only the person(s) using the computer can access the data
  - No means of concurrent access or data sharing

Engineering on the stand-alone system

- The engineering application (CAD, BIM, GIS, FEM, etc.) is used without an internet connection
- This is a ”traditional” setup that once was very common
  - Has not disappeared completely, though is becoming rare
    - When working on the move, network connection may not always be present
- Useful in cases where limited resources are sufficient
  - Limited data sets
  - Limited analysis
- No longer the most common way, but that does not mean it will (completely) disappear in the foreseeable future
  - Merely become rare enough that people will feel annoyed and limited when forced to work this way

Advantages of using the stand-alone system

- No internet connection required
  - Internet services cannot cause failures
- Conceptually simpler
  - All elements are local and thus can be locally managed
  - With admin access, the user can(theoretically) fully access everything

Disadvantages of a stand-alone system

- **Limited resources**
  - CPU speed, memory, storage space
- Limited software availability
  - Every piece of analysis software needs to be installed
  - Every piece of analysis software requires stand-alone license (or license on-loan from a license pool)
  - Missing or unauthrorized functionality is difficult to access
- Limited means of sharing the work
  - Off-line data transfer between computers is cumbersome
- (Limited support)
  - Documentation, peer support, commercial support

The Connected Computer

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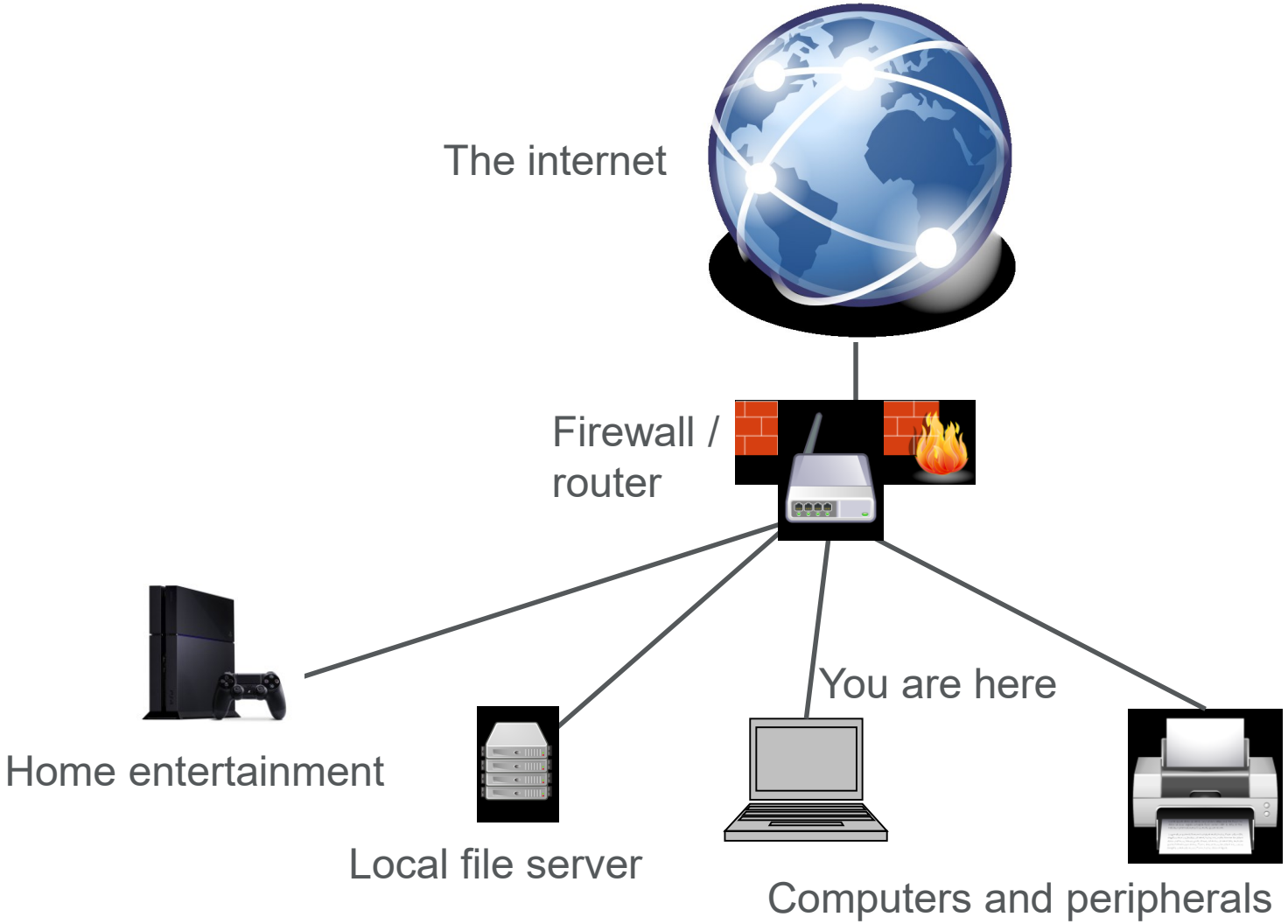
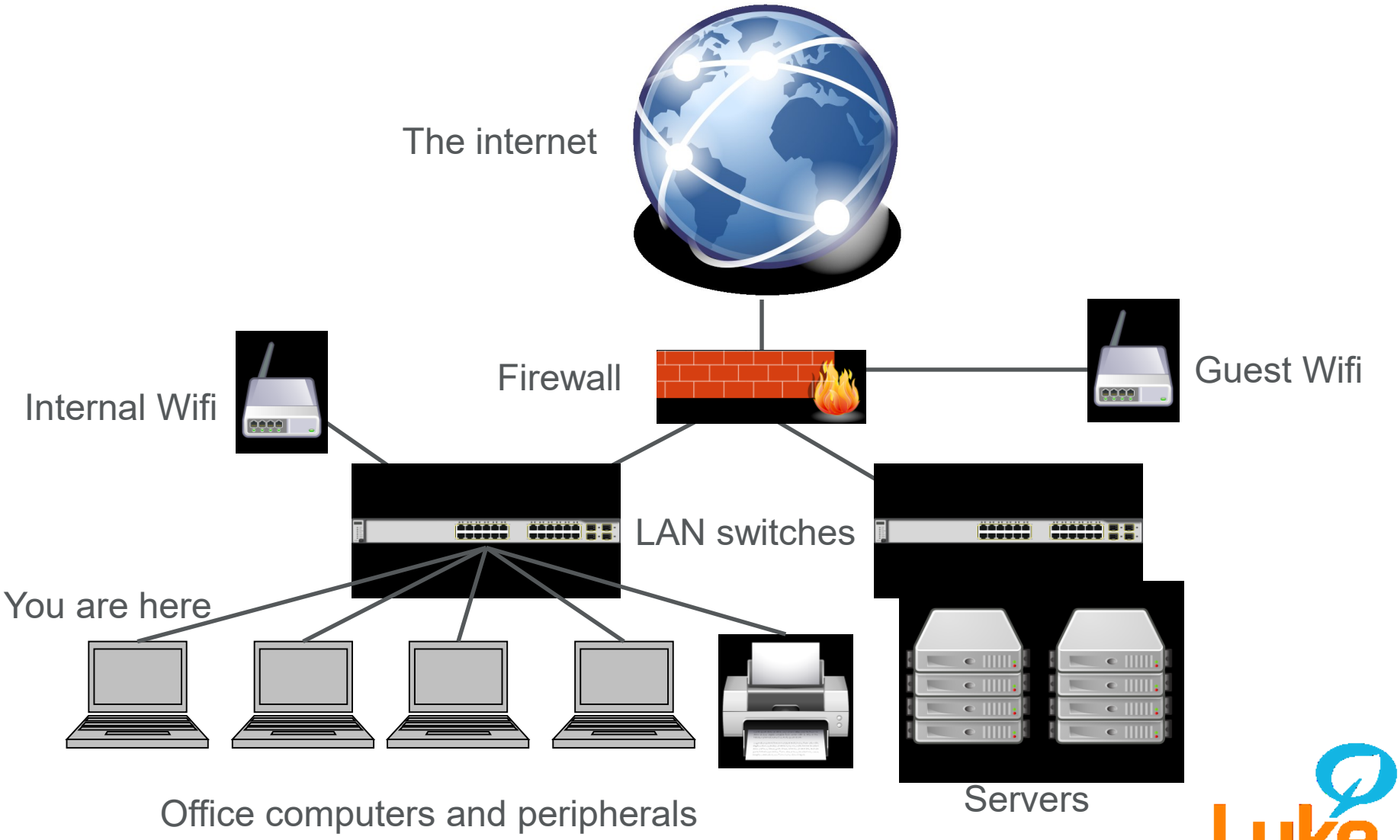
A (very) abstract model of a home network



A (very) abstract model of an office network



Engineering on the connected system

Engineering on the connected system

- The analysis is still primarily handled locally
  - Limited by CPU, memory, local storage
- The engineer still interacts with the data through engineering software, using tools available on the local machine
  - It may be possible to download missing tools or licenses on demand
- The system has access to internet resources
  - Software licenses
  - Data
  - Documentation and support

Engineering on the connected system

- Data can be shared over internet
  - In batches: input is retrieved, analysis is made, output is sent out
  - On demand: remote file system or database access
- Data access can be concurrent
  - If data is shared over the internet, many people can use it simultaneously
- The current default classroom setup
- Extremely common in practice
  - In high-demand computing tasks is constantly losing ground to cloud-based solutions

Advantages of the connected system

- Ability to find information on the internet
  - Documentation, best practices, practical examples, peer support
- Easier software availability
  - Software can be activated from a license pool
  - Ability to use larger range of software features
    - Required features can be activated via the pool
- Easier to share work
  - On-line file systems or databases

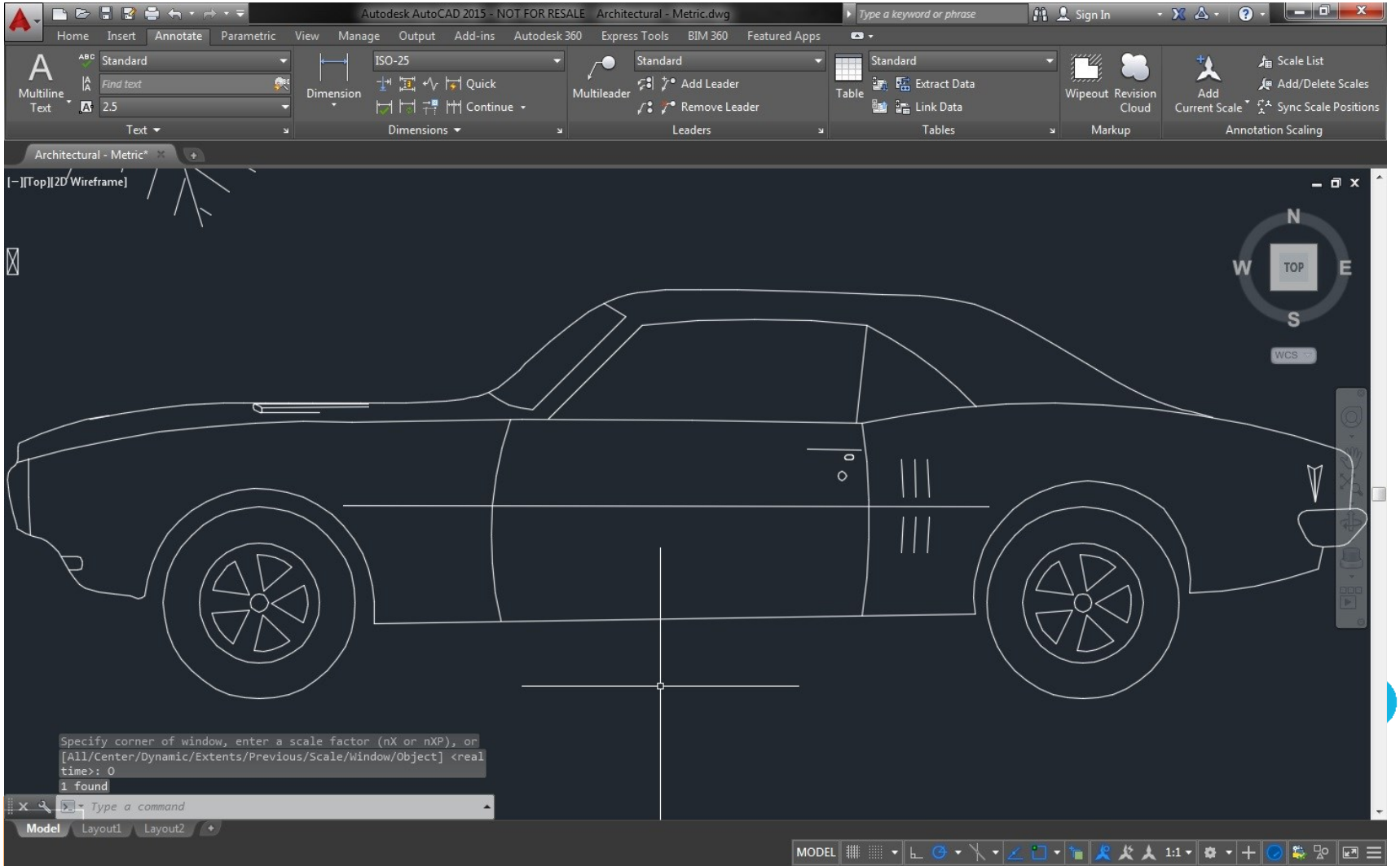
Disadvantages of the connected system

- **Limited resources**
  - CPU speed, memory, storage space
- Requires an internet connection
  - Bandwidth, service availability
- Problems in setup may not be limited to the computer itself
  - Connection problems, network setup problems, network security problems, etc.
  - Intensive use of internet resources may create calculation bottlenecks
    - Remote data access, remote access to licenses
- Limited software availability
  - Too few licenses in the license pool
- Tech support may be required in order to solve problems
  - Bad network setup may make things difficult
  - Good network setup is typically invisible

Connected examples

- Pretty much all desktop engineering software are either completely stand-alone, or require an internet connection to fetch a license
  - At aalto many licenses are managed through CSC
- ArcGIS, AutoCad, Matlab, etc. are examples of software that have traditionally been used in this manner
- Internet connection makes it also possible to include different kinds of web-based services
  - Thus work flow is not just design anymore, but it can also include system maintenance or monitoring

Connected Examples



The Computer and the Cloud

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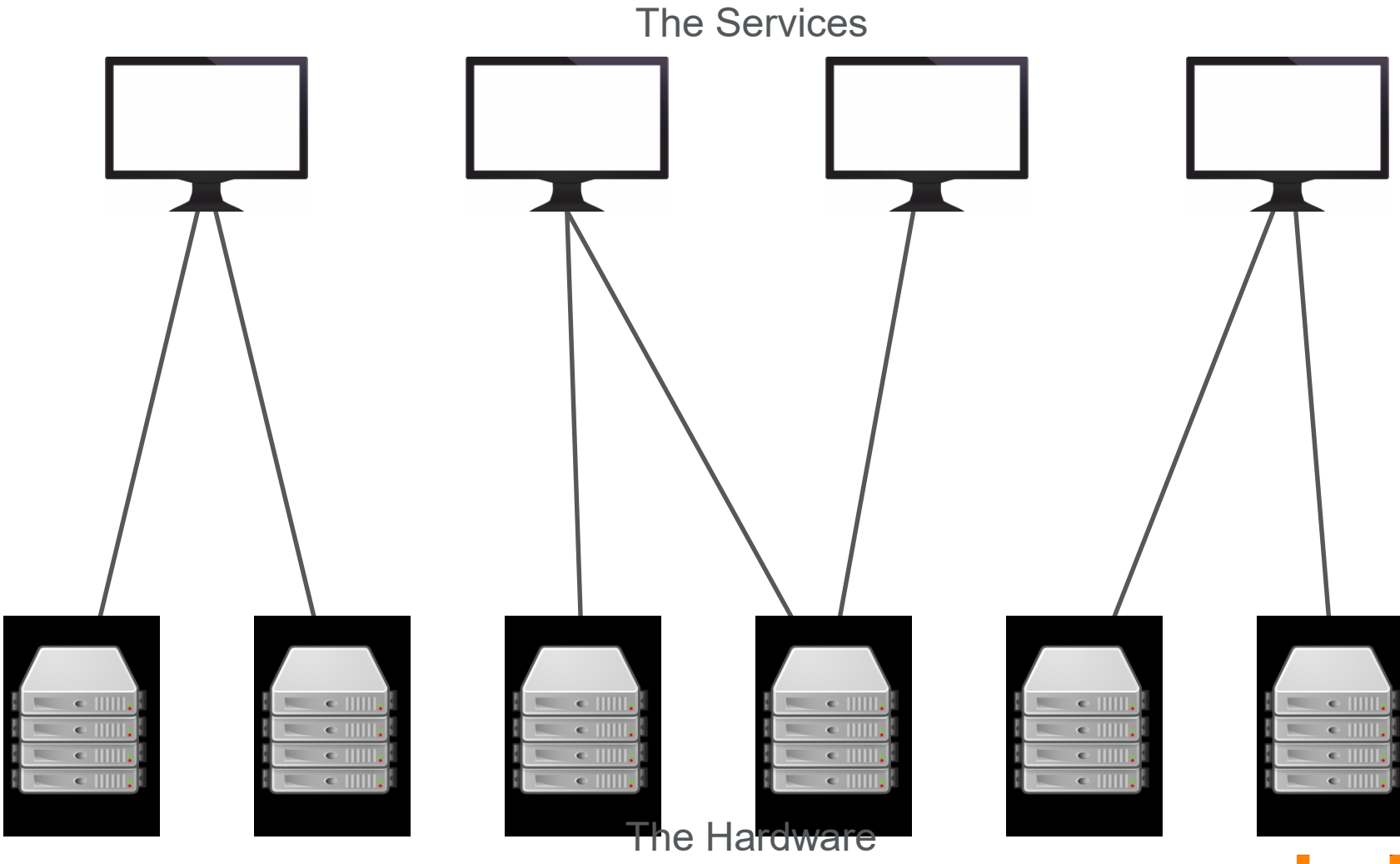
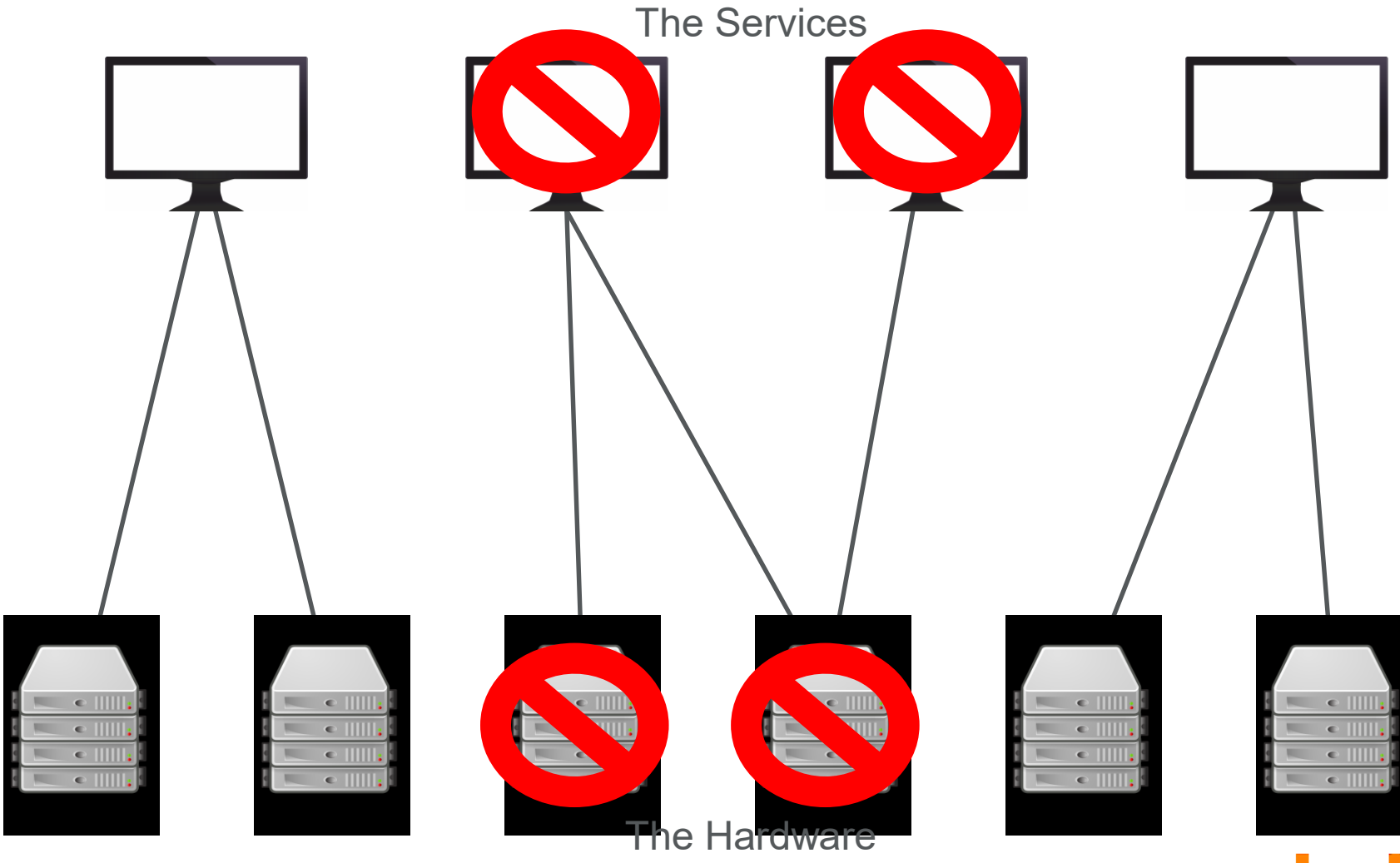
Cloud Computing: a very short introduction

- Cloud computing is a computing paradigm where massively scalable computation capabilities are delivered as a service over internet
- Instead of buying computational capability as hardware, computational capability is bought as a service from a service provider as needed
  - Typically the majority of hardware capability is unused as capability must be estimated according to peak demand
  - Buying capability as service removes the need to maintain hardware and utility software
  - Allows cost reductions (no need to buy hardware) and organizational agility (capability can easily be scaled according to need)

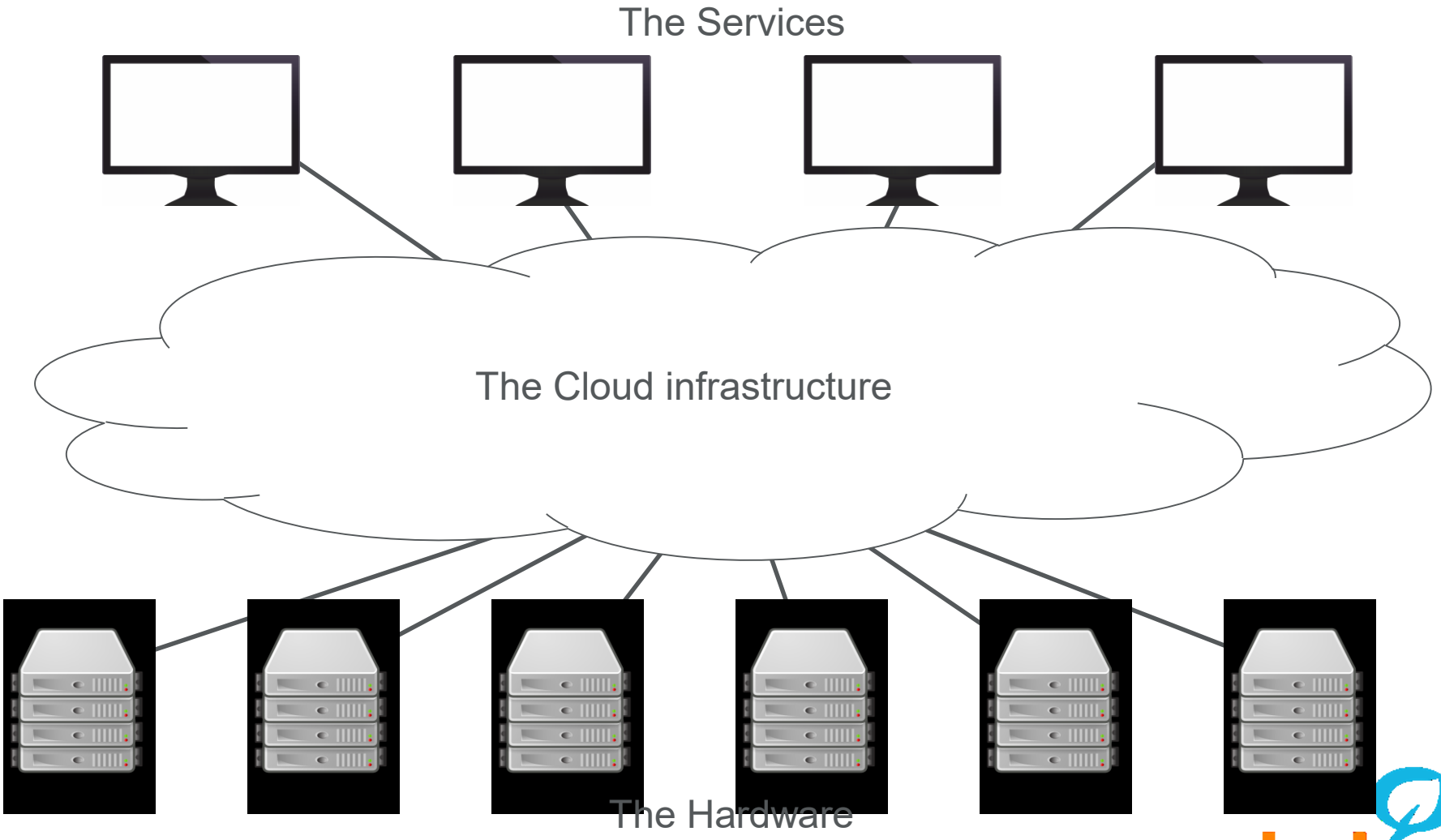
A (very) abstract model of traditional web services



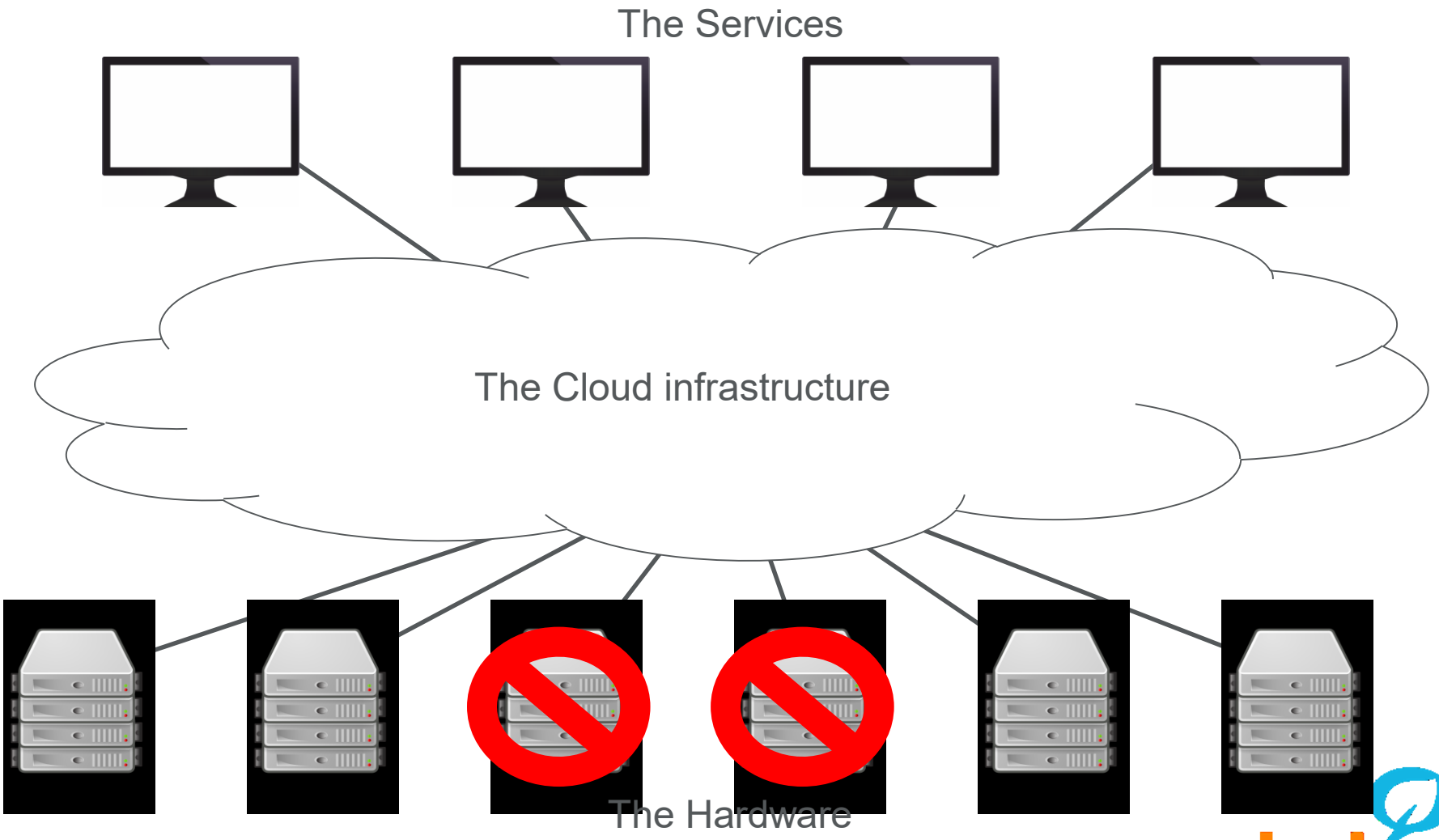
A (very) abstract model of traditional web services



A (very) abstract model of cloud computing



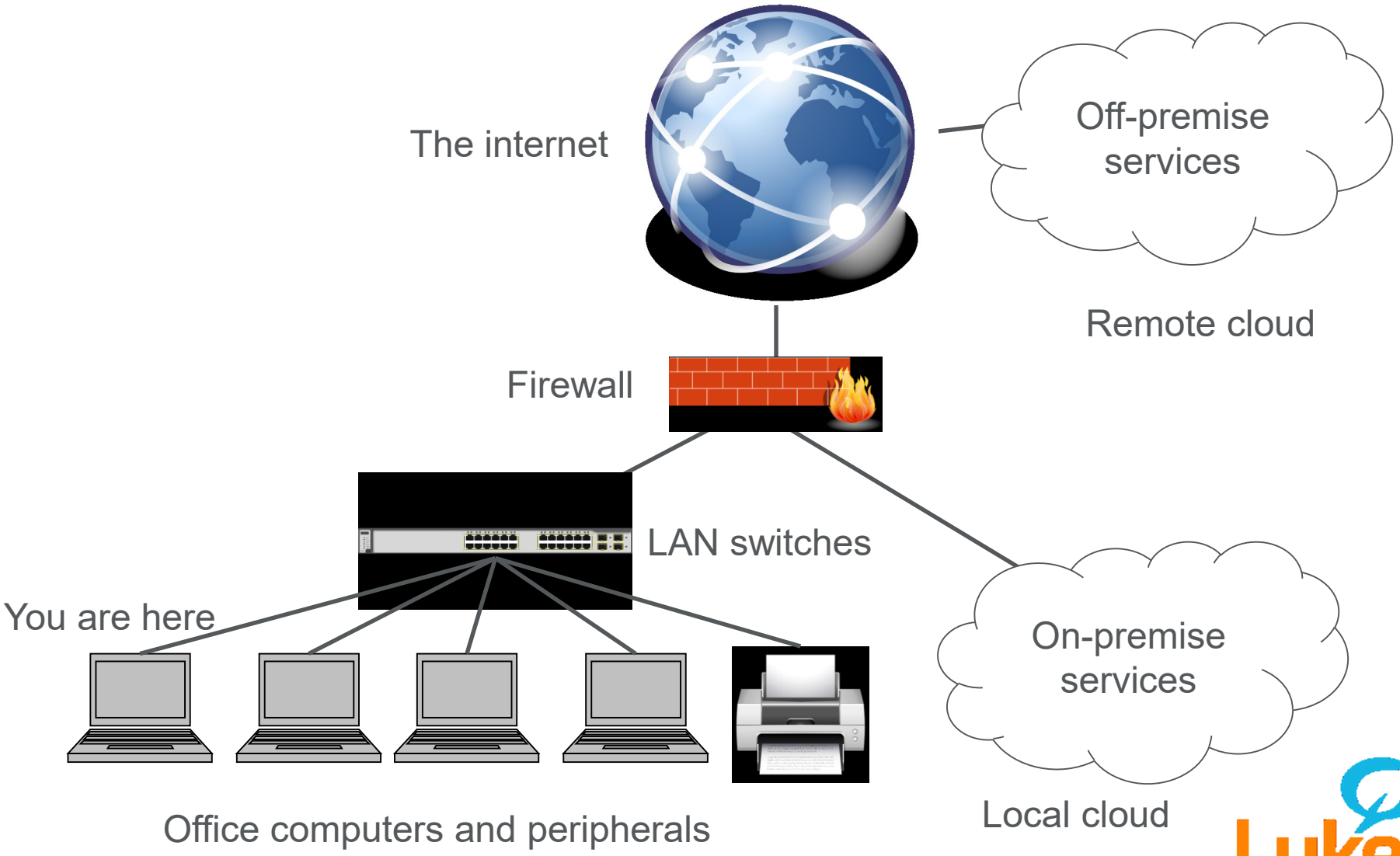
A (very) abstract model of cloud computing



Technological enablers of Cloud computing

- Broadband networks
  - High bandwidth, low latency, reliable, and fault-tolerant data delivery
- Data center technology
  - Modular hardware grouped together and maintained together with high level of automation and reliability
  - Provides enough computation power for a large number of services
- Virtualization
  - Decouples physical hardware from network services provided
- Web technologies
  - Modern web technologies allows services to be easily deployed, shared, and accessed on the internet

A (very) abstract model of a cloud-enabled office network (wifi excluded for clarity)



Different types of cloud services

- Cloud services can be characterized in many different ways, this is merely one
- Software as a Service (SaaS): cloud is used to run an application – the application can be accessed through some client program
  - Webmail, **engineering software**
- Platform as a Service (PaaS): cloud is used to provide a platform to run specific customer software
  - Cloud-based **OS platform,** on which software can be run
- Infrastructure as a Service (IaaS): cloud is used to provide the customer with fundamental computing resources
  - Cloud storage, **virtual machine**

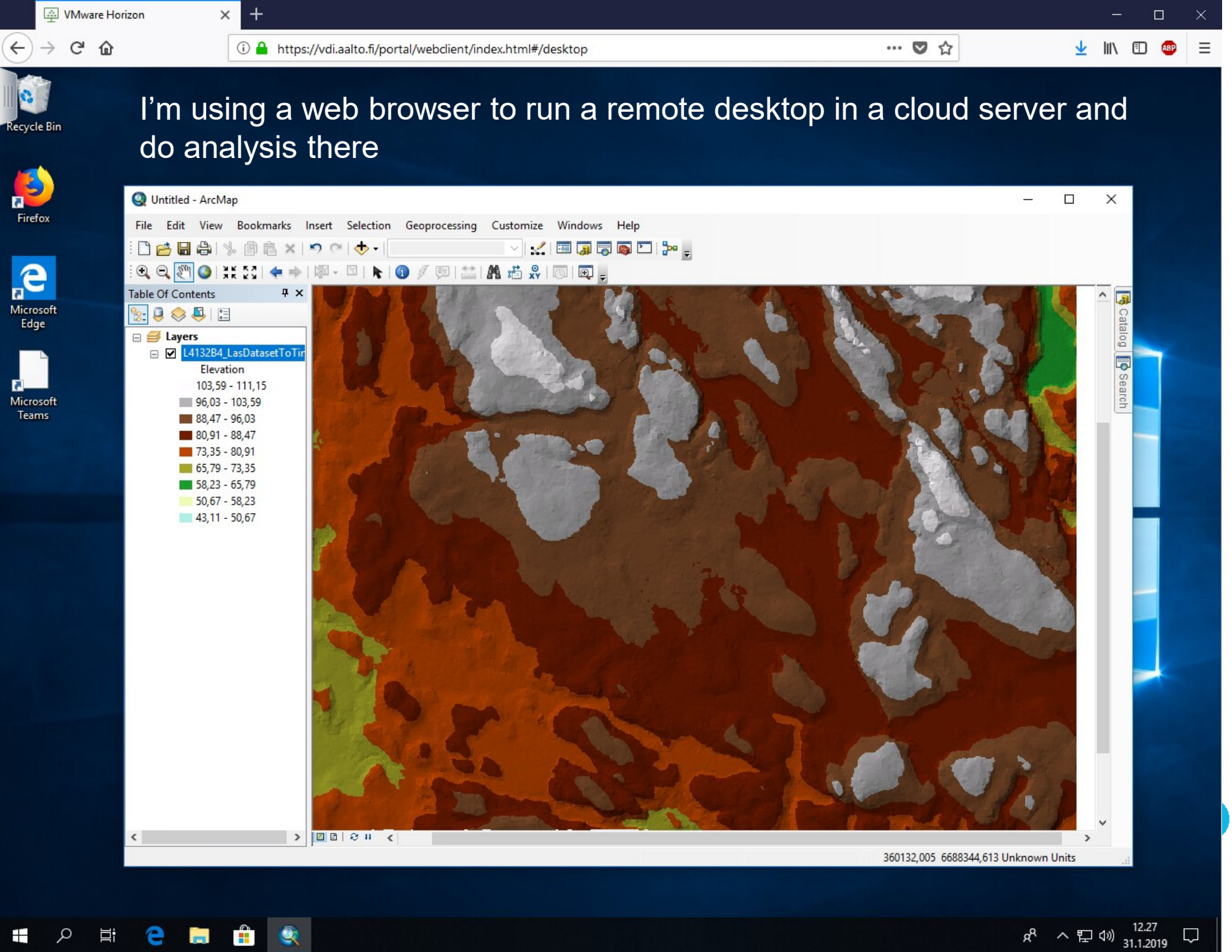
Engineering in the cloud

Engineering in the cloud

- **Instead of doing the analysis locally, the computation is done in the cloud**
  - CPU, memory, and storage capacity can be scaled upon demand
  - Especially good for problems that can be solved in parallel
- Compared to on-site software, cloud-enabled analysis is more often done with custom software
  - The field is not as mature, but maturing fast
- Many existing software solutions now have cloud-enabled (or cloud-depending) versions
  - Instead of running an engineering software on the local computer, the engineer runs a client software that communicates with the cloud

Engineering in the cloud

- The degree of control the user has over the cloud interface depends on the application
  - What is the best means to take advantage of cloud is very situation-dependent
- The degree of transparency of the cloud to the user also varies
  - Existing software that add cloud functionality (or move functionality to the cloud) can make the cloud transparent
  - Custom analysis software can make the cloud explicit
  - Appropriate cloud software client can move the whole work into the cloud without it being (immediately) visible


VMware Horizon
https://vdi.aalto.fi/portal/webclient/index.html#/desktop
I’m using a web browser to run a remote desktop in a cloud server and do analysis there
Recycle Bin
Firefox
Microsoft Edge
Microsoft Teams
Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
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Elevation
103,59 - 111,15
96,03 - 103,59
88,47 - 96,03
80,91 - 88,47
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Advantages of the Cloud

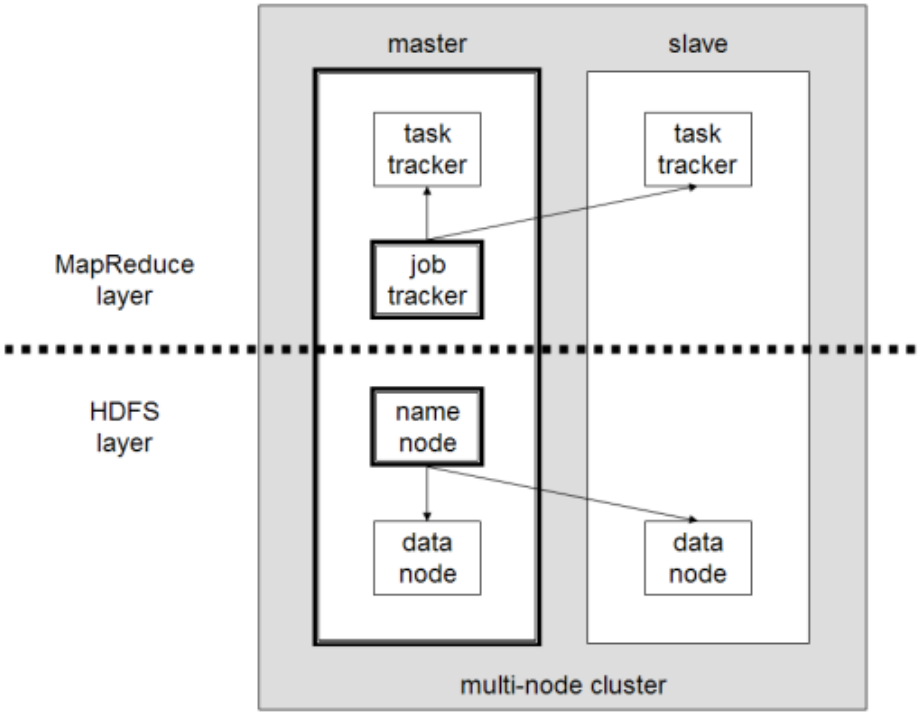
- **Very large computation and storage capacities**
  - Most useful in problems that can be parallelized
- **Ability to quickly solve significantly larger engineering problems than locally**
- Capacity can be bought according to need
- Redundancy and reliability can be better
- Ability to easily access the same analysis from any computer

Disadvantages of the Cloud

- Most useful with very large, highly parallel problems
  - Less useful with smaller problems, or problems that cannot be parallelized
- The data transfer can become a computational bottleneck
  - Very dependent on high-speed internet connection, especially when large amounts of data are transferred between local and remote machines
  - Latency can be an annoyance
- Optimal use of cloud resources may require more help from computer experts than local analysis
  - There can be more moving parts in the problem
- Data location and security can be problematic

Cloud-specific analysis software

- When talking about **big data** and cloud services, you will most likely encounter Hadoop and Mapreduce
  - Hadoop is a software framework for distributed storage of very large data sets
  - MapReduce is a framework for parallerized calculation of large problems



Cloud Examples

ArcGIS in the Cloud

Esri Managed Cloud Services provides you with ready-to-use instances of ArcGIS running in the cloud, delivered by GIS professionals, including:

- Infrastructure
- Software
- Deployment and testing
- Data management
- 24/7 support and monitoring

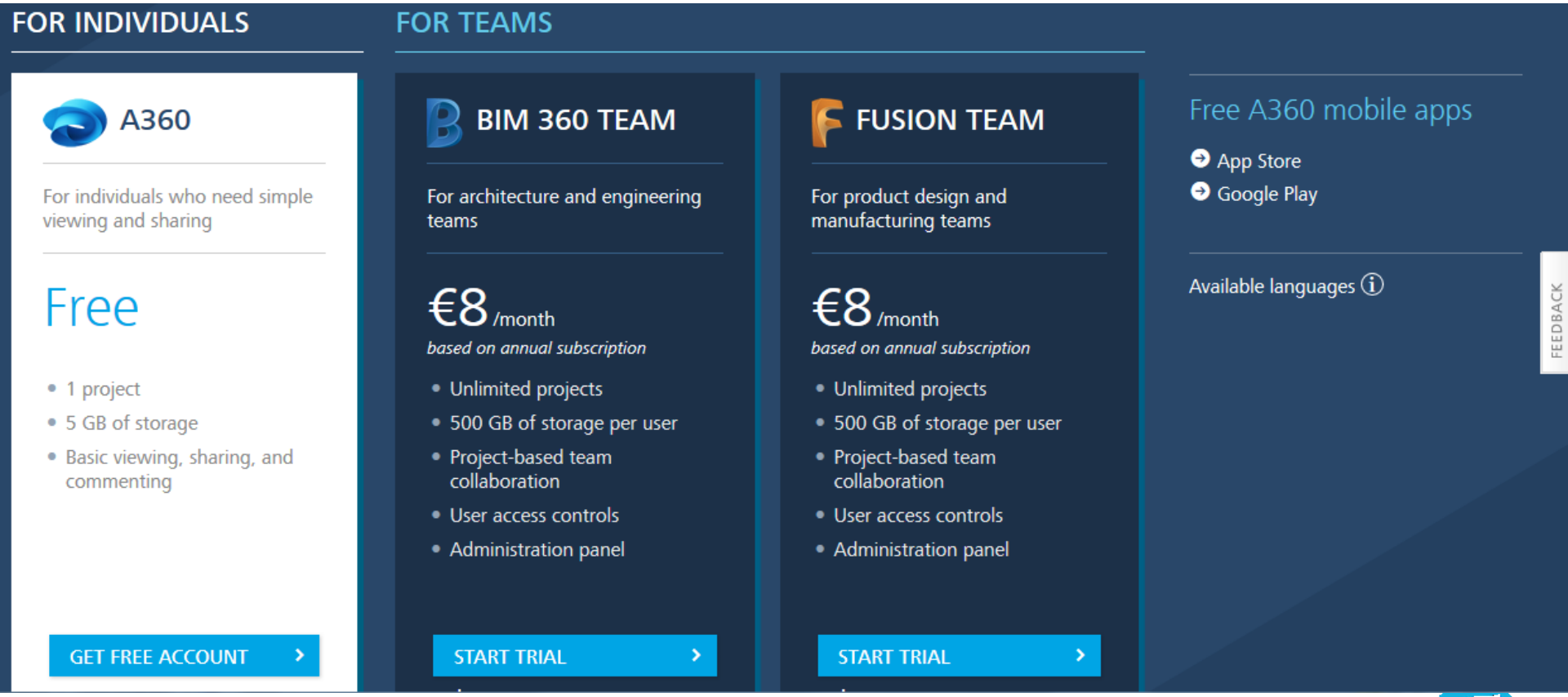
Our cloud experts also provide a valuable resource to organizations looking for the appropriate deployment pattern, technical architecture, and infrastructure capacity.

Create, collaborate, and compute—in the cloud

Whether you need to work with others on a mockup or render a 3D image, adding cloud services to your Autodesk software helps you do your job faster.

- Finish computation-intensive tasks in minutes or hours instead of days.
- Collaborate with as many people as you need.
- Render 3D images and perform a variety of analyses—nearly anytime, anywhere.
- Update project plans with your team—instantly—from your mobile devices.
- Extend BIM management to the entire team.
- Improve quality, safety, and commissioning processes in the field.

Cloud Examples



The Three-Layer Software Architecture

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The user interface and the program

- **The user interface is not the program!**
  - The UI is a means to view the program
    - Compare e.g. to a car's dashboard
- "Underneath" the UI there are typically a lot of (normally) invisible functionality that actually executes the program's internal logic
- To understand what a program does, you must understand this logic
  - A program may have several ways to accomplish something
  - The different ways may have significant differences in the implementation that affect the actual work and the result

Software Architectures

- Each (non-trivial) software has an **architecture**, which is the basic structure and design philosophy of the program
- Architecture is a design tool, not an aspect of the implementation
- Understanding of the architecture allows you to understand the program better
  - Understanding the program better allows you to be able to use it better
- There are numerous different architectural styles for software
  - Component-based is concerned with separation of different functionality in the program
  - Data-centric is concerned with how to handle the data
  - Event-driven is built around detection and handling of different activities that occur in the software
  - Service-oriented is built around independent services that provide business activities to each other

The Layered Software Architecture

- A way of looking at a program as a stack consisting of different layers, where each layer is responsible for specific activities
- The layered architecture divides a software into **layers**
  - Each layer has a distinct purpose
  - Each layer interacts with the layer below and above itself
  - On top is typically the presentation (UI) layer
  - At the bottom is a data management layer
- Perhaps the most important layered architecture is the Internet protocol suite
  - Used to model all data transfer between computers in the internet
  - Has between three and seven layers, depending on the source (and thus the point of view)

The Three-Layer Model

- On top is the presentation layer, which handles interaction with users
  - This is what you see!
- In the middle is the logic layer, which coordinates the application, calculates, and transfers data between the top and bottom layers
  - This holds the program functionality
- At the bottom is the data layer, which handles data storage, retrieval, and modification
  - This makes sure the work is saved

Presentation

Logic

Data

The Three-Layer Model

- What you see is the presentation layer
- What does the majority of the work is the logic layer
- What makes sure the work is saved (or, if needed, discarded) is the data layer
- In an engineering program
  - The user interface is the presentation layer
  - The different analysis tools and other functionality that can be called from the UI are logic layer
  - The functionality that keeps the UI presenting the current view of the work is a combination of UI and logic
  - Saving and loading the data belongs to the data layer